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Research Paper

Formulation and Evaluation Study on Herbal Toothpaste

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ABSTRACT

This review article presents a comprehensive evaluation of a herbal toothpaste formulated using traditional medicinal ingredients such as neem stem and bark, babul leaves, guava leaves, kalmi bark, camphor, and honey, combined with essential excipients like calcium carbonate, glycerin, sodium lauryl sulfate, and preservatives. The study highlights the rising preference for natural oral-care products and emphasizes the therapeutic significance of the selected botanicals, which exhibit antimicrobial, anti-inflammatory, astringent, and cleansing properties beneficial for maintaining oral hygiene. The formulation process, along with physical, chemical, and microbiological evaluation parameters—such as pH, spreadability, abrasiveness, foaming capacity, and antimicrobial activity—demonstrates that the herbal toothpaste provides effective plaque control, gum strengthening, and microbial reduction with minimal side effects. Findings from the review suggest that the developed herbal formulation is a safe, economical, and efficient alternative to conventional chemical-based toothpaste, offering considerable potential for future research, optimization, and commercial application in the natural oral-care sector.

INTRODUCTION

1.1. Overview of Oral Hygiene and Toothpaste:-

Oral hygiene is a fundamental component of general health, as the oral cavity serves as the primary gateway to the digestive and respiratory systems. Maintaining a clean and healthy mouth helps prevent a wide range of dental conditions, including dental caries, periodontal diseases, halitosis, plaque accumulation, and gum inflammation. Effective oral hygiene practices—such as regular tooth brushing, flossing, and the use of therapeutic oral products—play a crucial role in safeguarding oral tissues, preserving tooth structure, and promoting overall well-being.

Toothpaste is one of the most widely used oral hygiene products globally, functioning as an

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adjunct to mechanical cleaning by enhancing plaque removal, reducing bacterial load, and delivering active agents to the teeth and gums. Modern toothpaste formulations generally include abrasives, surfactants, humectants, binders, preservatives, and flavouring agents. These components work synergistically to remove debris, polish tooth surfaces, prevent microbial growth, maintain moisture, and improve user acceptability.

In recent years, the demand for herbal and natural alternatives to conventional toothpaste has grown significantly. Concerns over synthetic chemical additives, increasing awareness of natural remedies, and interest in traditional medicinal systems such as Ayurveda have contributed to this shift. Herbal toothpastes incorporate plant-based ingredients rich in phytochemicals, offering antimicrobial, anti-inflammatory, astringent, and antioxidant benefits. As a result, herbal formulations are being widely explored as safer, eco-friendly, and effective solutions for maintaining oral hygiene while minimizing adverse effects associated with synthetic components.

1.2. Rising Demand for Herbal Dental Care:-

The demand for herbal dental care products has increased significantly over the last decade due to growing consumer awareness about the potential side effects of synthetic chemicals commonly used in conventional toothpastes. Modern consumers are increasingly shifting toward natural and plant-based products that are perceived as safer, milder, and environmentally friendly. This shift is particularly evident in oral care, where the mucosal absorption of chemical ingredients can raise safety concerns. As a result, herbal formulations are gaining preference for daily dental hygiene.

Several factors contribute to this trend. First, there is a global resurgence of traditional medicinal systems such as Ayurveda, Unani, and Traditional Chinese Medicine, which emphasize the therapeutic benefits of herbs for maintaining oral health. Ingredients like neem, babul, guava, and cloves have long been recognized for their antimicrobial, anti-inflammatory, and healing properties, making them popular choices in herbal toothpaste formulations

Second, consumers are seeking alternatives that avoid synthetic surfactants, artificial colors, preservatives, and fluoride—especially for children and individuals with sensitivity issues. Herbal toothpastes are viewed as gentle yet effective, offering solutions for problems such as gingivitis, plaque buildup, mouth ulcers, and halitosis.

Third, the rise of wellness culture and the influence of natural product marketing have significantly increased the acceptance of herbal oral care. The expansion of the global herbal toothpaste market—supported by endorsements from dentists, researchers, and regulatory bodies—continues to strengthen this demand.

Overall, the growing inclination toward natural health, safety, sustainability, and holistic well-being has positioned herbal toothpaste as a preferred choice among consumers, driving continuous innovation and research in the field of herbal dental care.

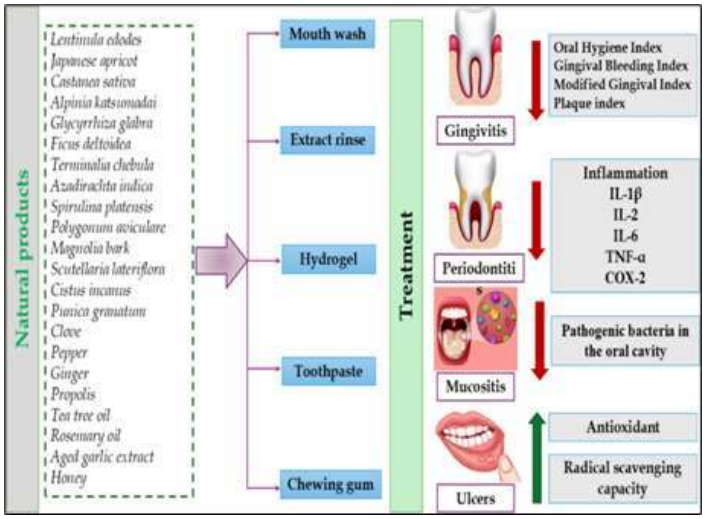

Figure 1 Natural Product

Role of Herbal Ingredients in Oral Health:-

Herbal ingredients have been widely recognized for their therapeutic potential in maintaining oral hygiene and preventing common dental problems such as plaque formation, gingivitis, halitosis, and microbial infections. Unlike synthetic agents that may cause side effects such as mucosal irritation or altered taste, herbal components provide a safer, biocompatible, and holistic approach to oral care. The following key herbal ingredients used in the formulation play significant roles in promoting oral health:

1.2.1. Neem Stem and Bark:- Neem (Azadirachta indica) possesses strong antibacterial, antifungal, and anti-inflammatory activities. It helps reduce dental plaque, prevents gingival bleeding, and inhibits pathogens like *Streptococcus mutans* responsible for tooth decay. Neem's natural bitterness also discourages bacterial adhesion to the teeth and gums.

1.2.2. Babul (Acacia arabica) Leaves:- Babul leaves exhibit astringent and anti-plaque properties. They help tighten gum tissues, reduce inflammation, and strengthen the periodontal structure. Babul is traditionally used for tooth cleaning due to its effective antimicrobial capability against oral pathogens.

1.2.3. Guava (Psidium guajava) Leaves:- Guava leaves are rich in flavonoids, tannins, and antioxidants. Their anti-inflammatory and antibacterial effects help soothe gums, reduce swelling, and prevent plaque formation. They also contribute to the reduction of halitosis due to their natural deodorizing properties.

1.2.4. Kalmi Bark (Bridelia retusa):- Kalmi bark contains tannins and phenolic compounds with notable astringent and antimicrobial actions. It helps protect gums, prevents microbial colonization, and contributes to the firmness of oral tissues.

1.2.5. Camphor:- Camphor exhibits mild analgesic, antiseptic, and refreshing properties. It helps relieve minor oral discomfort, inhibits bacterial growth, and contributes to a pleasant cooling sensation in the mouth.

1.2.6. Honey:- Honey acts as a natural humectant and possesses antimicrobial, soothing, and wound-healing properties. Its enzymatic activity produces hydrogen peroxide, which exerts bacteriostatic effects beneficial for oral health. Additionally, honey aids in

maintaining moisture and texture of the toothpaste.

❖ **Overall Role of Herbal Ingredients:-**

Collectively, these herbal components:

- Inhibit harmful oral microorganisms
- Reduce inflammation and promote gum health
- Prevent dental caries and plaque buildup
- Freshen breath naturally
- Provide a safe and chemical-free alternative to synthetic toothpaste formulations

Thus, the integration of herbal ingredients in toothpaste supports effective oral hygiene while minimizing adverse effects, making them suitable for long-term use.

1.3. Scope of the Review:-

This review focuses on the comprehensive understanding of herbal toothpaste formulation and its evaluation parameters, with specific emphasis on the ingredients presented in the attached formulation table. It covers the therapeutic relevance of traditional herbal components such as neem, babul, guava, kalmi bark, and camphor in oral care, along with essential excipients like calcium carbonate, glycerin, sodium lauryl sulfate, and preservatives that contribute to the overall product performance. The review outlines the formulation rationale, preparation methods, and analytical techniques used to assess quality, safety, and efficacy.

Additionally, the scope includes an examination of current research trends, comparative effectiveness of herbal vs. conventional toothpaste, regulatory considerations, and potential areas for innovation within herbal dentifrices. This review aims to provide a detailed scientific foundation for understanding how herbal toothpaste is developed, optimized, and evaluated, ultimately serving as a reference guide for researchers, formulators, and healthcare professionals interested in natural oral care products.

Figure 2 Herbal Toothpaste

FORMULATION TABLE

Table 1 Formulation Table

Sr. No	Ingredient	Quantity	Properties / Role in Toothpaste
1	**Neem stem and bark**	**0.5 g**	Strong antibacterial, antifungal; prevents gingivitis; reduces plaque formation.
2	**Babul leaves**	**0.5 g**	Natural astringent; strengthens gums; reduces gum bleeding; antimicrobial action.
3	**Guava leaves**	**0.5 g**	Rich in flavonoids; anti-inflammatory; effective against oral bacteria; soothes mouth ulcers.
4	**Kalmi bark**	**0.5 g**	Astringent and antimicrobial; helps tighten gums and reduce swelling.
5	**Camphor**	**0.5 g**	Provides cooling and analgesic effect; reduces toothache and gum pain; mild antiseptic.
6	**Honey**	**0.5 g**	Natural humectant; antibacterial due to hydrogen peroxide release; enhances taste.

7	**Calcium carbonate**	**3.5 g**	Mild abrasive; removes plaque and stains; strengthens enamel by calcium supply.
8	**Glycerin**	**2.0 ml**	Humectant; prevents drying; improves texture and smoothness of toothpaste.
9	**Para-hydroxy benzoic acid (Paraben)**	**0.3 g**	Preservative; prevents microbial growth and increases shelf life.
10	**Sodium lauryl sulfate (SLS)**	**0.5 g**	Foaming agent; helps in even distribution of toothpaste and debris removal.
11	**Sodium chloride**	**0.2 g**	Mild antiseptic and astringent; reduces swelling; helps cleanse oral cavity.
12	**Distilled water**	**10 ml**	Solvent; provides required consistency for toothpaste base.

HERBAL TOOTHPASTE FORMULATION

Rationale for Ingredient Selection:-

The formulation of an effective herbal toothpaste requires a careful combination of botanicals and excipients that collectively provide antimicrobial action, plaque removal, soothing effects, abrasiveness, preservation, and consumer acceptability. Each ingredient included in the formulation has been selected based on its scientifically established therapeutic properties, traditional medicinal relevance, and compatibility within a semi-solid dental preparation.

1. **Neem Stem and Bark (0.5 g):-**

Neem possesses strong antibacterial, antifungal, and anti-inflammatory activities. It helps reduce plaque formation, inhibits pathogenic oral bacteria such as *Streptococcus mutans*, and promotes overall gum health. Its astringent properties also help maintain oral hygiene naturally.

2. **Babul Leaves (0.5 g):-**

Babul (Acacia arabica) is traditionally known for strengthening gums and reducing gingival inflammation. Its high tannin content provides astringency, which supports gum tightening and reduces bleeding. It also acts synergistically with neem for antimicrobial protection.

3. **Guava Leaves (0.5 g):-**

Guava leaves contain flavonoids such as quercetin and possess potent antimicrobial and anti-plaque properties. They also aid in soothing inflamed gums and assist in controlling bad breath due to their deodorizing effect.

4. **Kalmi Bark (0.5 g):-**

Kalmi bark (often associated with *Cerbera odollam* or regional variants) is added for its astringent, antimicrobial, and cleansing properties. It contributes to gum strengthening and supports the herbal blend in controlling oral pathogens.

5. **Camphor (0.5 g):-**

Camphor acts as a mild analgesic and cooling agent, providing a refreshing sensation in the mouth. Its antimicrobial properties help reduce oral microbial load and contribute to a pleasant sensory profile.

6. **Honey (0.5 g):-**

Honey has natural antibacterial, healing, and soothing properties. It helps reduce oral inflammation, promotes gum healing, and improves the taste and acceptability of the formulation.

7. **Calcium Carbonate (3.5 g):-**

Calcium carbonate is selected as the mild abrasive to aid in mechanical plaque removal without damaging enamel. It ensures desirable texture, polishing action, and viscosity within the toothpaste.

8. **Glycerin (2.0 g):-**

Glycerin acts as a humectant, retaining moisture and preventing the toothpaste from drying. It contributes to a smooth consistency and enhances the spreadability of the formulation.

9. Para-Hydroxy Benzoic Acid (0.3 g):-

Used as a preservative, this compound prevents microbial growth within the formulation, ensuring stability and safety over prolonged storage.

10. Sodium Lauryl Sulfate (0.5 g):-

SLS is included as a surfactant and foaming agent, improving cleansing action and enhancing user perception. It helps distribute the formulation evenly across the oral cavity.

11. Sodium Chloride (0.2 g):-

Sodium chloride helps in osmotic cleansing of gums, reduces bacterial growth, and contributes to an overall refreshing effect.

12. Distilled Water (q.s.):-

Used as the universal solvent, distilled water facilitates dissolution, maintains the semi-solid structure, and ensures purity without introducing contaminants.

Description of Formulation Components:-

Neem Stem and Bark:-

Neem (Azadirachta indica) is widely known for its potent antibacterial, antifungal, and anti-inflammatory properties. Its stem and bark contain bioactive compounds such as nimbidin, azadirachtin, and flavonoids that help inhibit oral pathogens responsible for plaque formation, gingivitis, and halitosis. In herbal toothpaste, neem acts as a natural antimicrobial and astringent, supporting gum health and reducing microbial load in the oral cavity.

Table 1 Description of Neem

Category	Description
Botanical Name	*Azadirachta indica*
Family	Meliaceae
Part Used	Stem, Bark (powder, extract, decoction)
Common Names	Neem, Margosa, Indian Lilac
Physical Characteristics	Light brown bark, bitter taste, strong aromatic odor; rich in tannins and resin.
Phytochemical Constituents	Nimbidin, Nimbin, Azadirachtin, Gedunin, Quercetin, Tannins, Flavonoids, Sterols.
Primary Properties	Antibacterial, Antifungal, Antiviral, Anti-inflammatory, Antiplaque, Analgesic, Antioxidant.
Mechanism of Action in Oral Care	Inhibits growth of *Streptococcus mutans* and plaque-forming bacteria; reduces inflammation in gingiva; strengthens gums by tannin-induced astringent effect; disrupts bacterial cell wall integrity.
Benefits in Toothpaste	Controls plaque, reduces gum bleeding, prevents gingivitis, freshens breath, heals mouth ulcers, provides mild whitening effect.
Traditional Uses	Chewing neem sticks as natural toothbrush (Datun), treatment of gum diseases, antiseptic for oral infections.
Safety / Toxicity	Generally safe for topical/oral rinse use in low concentration; excessive ingestion may cause stomach irritation due to bitter alkaloids.
Functional Role in Formulation	Herbal antimicrobial agent, gum-strengthening astringent, deodorizing agent, natural therapeutic ingredient.

Figure 4 Neem

Babul Leaves:-

Babul (Acacia arabica) leaves are rich in tannins, flavonoids, and saponins. Traditionally used as a natural toothbrush ("datun"), babul strengthens gums, reduces bleeding, and provides a tightening effect due to its strong astringent nature. In the formulation, babul leaves contribute to plaque control, prevention of gum recession, and overall enhancement of periodontal health.

Table 2 Description of Babul Leaves

Parameter	Details
Botanical Name	*Acacia arabica* / *Vachellia nilotica*
Common Names	Babul, Kikar, Gum Arabic Tree
Plant Part Used	Leaves (also bark and pods in traditional use)
Family	Fabaceae
Phytochemical Constituents	Tannins, Flavonoids, Saponins, Alkaloids, Terpenoids, Gallic acid, Catechins
Primary Properties	Astringent, Antibacterial, Anti-inflammatory, Antioxidant
Mechanism of Action in Oral Care	• Tannins tighten gums and reduce bleeding• Antimicrobial compounds inhibit *Streptococcus mutans* and periodontal bacteria• Anti-inflammatory action reduces gingival swelling• Antioxidants protect oral tissues
Benefits in Toothpaste Formulation	• Strengthens gums• Controls plaque formation• Reduces gum bleeding• Prevents periodontal infections• Provides mild cleansing action
Traditional Uses	Used in Ayurveda for teeth cleaning (datun), gum strengthening, wound healing, sore throat, diarrhea, and skin infections
Safety & Toxicity	Generally safe in oral products; excessive use may cause mild dryness due to high tannin levels
Form Used in Toothpaste	Dried leaf powder or aqueous extract
Recommended Concentration	0.5–2% depending on formulation type

Figure 5 Babul Plant

Guava Leaves:-

Guava (Psidium guajava) leaves contain quercetin, tannins, and essential oils that possess remarkable antimicrobial and anti-inflammatory activities. They help in reducing swelling of gums, combating bad breath, and inhibiting growth of Streptococcus mutans. Their antioxidant profile also aids in healing minor

Table 3 Description of Guava

Parameter	Details
Botanical Name	*Psidium guajava*
Common Name	Guava leaves
Family	Myrtaceae
Useful Part	Leaves (fresh or dried)
Phytochemical Constituents	Flavonoids (quercetin), tannins, saponins, carotenoids, essential oils, phenolics
Key Biological Activities	Antibacterial, anti-inflammatory, antioxidant, astringent, wound-healing
Role in Herbal Toothpaste	Controls oral bacteria, reduces gum swelling, tightens gums, prevents plaque, heals mouth ulcers, freshens breath
Action Against Oral Pathogens	Effective against *Streptococcus mutans*, *Porphyromonas gingivalis*, *Lactobacillus*, *Candida albicans*
Mechanism of Action	Flavonoids inhibit bacterial growth; tannins tighten gums (astringent effect); antioxidants reduce inflammation
Benefits in Oral Care	Prevents gum bleeding, reduces plaque, relieves mouth ulcers, combats halitosis, improves gingival health
Safety / Toxicity	Generally safe in toothpaste concentrations; mild astringency may occur in high amounts
Form Used in Formulation	Fine powder, extract, or decoction
Recommended Concentration	0.5–2% in herbal toothpaste formulations
Compatibility with Other Herbal Ingredients	Works synergistically with neem, babul, clove, peppermint, and aloe vera

Figure 6 Guava Leaves

Kalmi Bark:-

Kalmi (often associated with *Callicarpa macrophylla* or regional equivalents) bark is traditionally used for its analgesic, astringent, and anti-inflammatory effects. Its phytochemicals help soothe irritated gums and reinforce oral tissues. In toothpaste formulations, kalmi bark enhances gum resistance, supports healing, and contributes to controlling microbial activity.

Table 5 Description of Kalmi Bark

Parameter	Details
Common Name	Kalmi Bark
Botanical Source	*Mitragyna parvifolia* (commonly associated), sometimes locally referred to under regional names
Family	Rubiaceae
Plant Part Used	Bark
Traditional Use	Used in Ayurveda for treating gum disorders, inflammation, pain relief, and wound healing
Appearance	Hard, brownish bark with irregular surface and slightly bitter taste
Phytochemical Constituents	Alkaloids, tannins, flavonoids, glycosides, saponins
Key Active Components	Tannins (astringent), flavonoids (antioxidant), alkaloids (bioactive antimicrobial action)
Medicinal Properties	Astringent, anti-inflammatory, antimicrobial, analgesic, wound-healing

Role in Herbal Toothpaste	Tightens gums, reduces gum bleeding, provides antimicrobial activity, prevents plaque formation
Mechanism of Action in Oral Care	Tannins act to tighten gum tissue; alkaloids inhibit oral pathogens; flavonoids reduce inflammation and oxidative stress
Benefits in Oral Health	Prevents gingivitis, reduces plaque, strengthens gums, freshens breath
Solubility	Partially soluble in water; many active compounds extract easily in aqueous decoctions
Dosage form in Toothpaste	Fine powder or aqueous extract
Safety & Toxicity	Considered safe in small concentrations; excessive use may cause mild irritation due to high tannin content
Storage Condition	Store in airtight container; protect from moisture, light, and contamination

Figure 7 Kalmi Bark & Leaves

Camphor:-

Camphor is a natural compound derived from Cinnamomum camphora. It provides a cooling, soothing sensation and is widely recognized for its mild analgesic and antimicrobial properties. In herbal toothpaste, camphor helps refresh breath, reduce oral discomfort, and contribute to the cleansing effect.

Table 6 Description of Camphor

Parameter	Details
Chemical Name	1,7,7-Trimethylbicyclo[2.2.1]heptan-2-one
Botanical Source	Obtained mainly from the wood of *Cinnamomum camphora* tree
Common Forms	Crystals, white powder, camphor oil
Nature / Appearance	White, waxy, transparent solid with a strong aromatic odor
Solubility	Slightly soluble in water, soluble in alcohol and oils
Odor & Taste	Strong, penetrating fragrance; cooling and slightly bitter taste
Class	Organic terpenoid; cyclic ketone
Key Phytochemical Activity	Terpenes, antioxidants, antimicrobial compounds
Primary Pharmacological Actions	Antimicrobial, analgesic, anti-inflammatory, antifungal, antipruritic
Mechanism of Action	Activates cold receptors (TRPM8), blocks pain signals, inhibits bacterial growth
Role in Oral Care / Toothpaste	Provides cooling sensation, reduces toothache, reduces gum swelling, mild antiseptic action
Benefits in Toothpaste	Refreshes breath, relieves minor oral pain, inhibits oral microbes, enhances flavor profile
Common Concentration Used	0.1–0.5% in toothpaste and oral care products
Compatibility	Compatible with glycerin, essential oils, herbal extracts; unstable at high temperature
Safety Level	Safe at low concentrations; excessive use may cause irritation
Toxicity (if overused)	Can cause nausea, burning sensation, or skin/mucosal irritation if used above recommended limits

Regulatory Status	Approved for topical/oral care use in limited concentrations (as per cosmetic guidelines)
Storage Conditions	Store in airtight container; protect from heat and direct sunlight due to volatility
Shelf Life	2–3 years under proper storage conditions

Figure 1 Camphor

Honey:-

Honey contains natural enzymes such as glucose oxidase, which produce hydrogen peroxide, giving it notable antibacterial activity. Its osmotic and antioxidant properties support healing of oral tissues. In toothpaste, honey improves taste, contributes to antimicrobial protection, and provides a natural humectant effect to maintain smooth texture.

Table 4 Description of Honey

Parameter	Details
Name	Honey
Source	Natural sweet substance produced by *Apis* bees from flower nectar
Nature	Thick, viscous, golden-colored liquid
Chemical Composition	• Fructose (38%) • Glucose (31%) • Water (17–20%) • Sucrose (1–2%) • Organic acids • Enzymes (glucose oxidase, catalase) • Vitamins (B-complex, C) • Minerals (Ca, Mg, K) • Phenolic compounds & flavonoids
Physical Properties	• Sweet taste • High viscosity • Hygroscopic (absorbs moisture) • Acidic pH (3.2–4.5) • Soluble in warm water
Biological Properties	• Antibacterial • Anti-inflammatory • Antioxidant • Wound healing • Antifungal
Mechanism of Antibacterial Activity	• Produces **hydrogen peroxide (H_2O_2)** through enzyme glucose oxidase • Low pH inhibits bacterial growth • High sugar content causes osmotic effect → dehydrates microbial cells
Role in Herbal Toothpaste	• Natural humectant (retains moisture) • Improves smoothness and spreadability • Prevents the paste from drying • Provides antimicrobial protection • Soothes gums and oral tissues • Enhances taste and mouthfeel
Oral Health Benefits	• Reduces gingivitis and gum inflammation • Helps heal mouth ulcers • Inhibits growth of *S. mutans*, *Lactobacillus* (caries-causing bacteria) • Reduces halitosis (bad breath) • Provides mild pain-relief in gum sensitivity
Safety Profile	• Safe for oral use • Non-toxic • May crystallize over time (normal property)
Stability	• Good shelf life due to low water activity • Stable under room temperature • Sensitive to high heat (can destroy enzymes)
Concentration Used in Toothpaste	0.5–5% depending on formulation
Regulatory Status	Allowed in oral care formulations (natural sweetener/humectant)

Figure 2 Honey

Calcium Carbonate:-

Calcium carbonate serves as a mild abrasive agent that assists in mechanical plaque removal without damaging enamel. It also contributes to polishing teeth, enhancing brightness, and maintaining an appropriate consistency in the toothpaste. Additionally, calcium ions aid in demineralization of tooth enamel.

Table 8 Description of Calcium Carbonate

Parameter	Details
Chemical Name	Calcium Carbonate
Chemical Formula	$CaCO_3$
Synonyms	Precipitated Calcium Carbonate (PCC), Ground Calcium Carbonate (GCC), Limestone powder, Chalk
Category / Type	Abrasive, Polishing agent, Opacifying agent, pH buffer
Appearance	Fine white, odorless powder
Odor	Odorless
Solubility	Insoluble in water; soluble in dilute acids with effervescence
Particle Size	Typically 1–10 microns (varies depending on grade)
pH (10% dispersion)	~9–10 (slightly alkaline)
Bulk Density	0.7 – 0.9 g/cm³
Stability	Stable under normal conditions; incompatible with strong acids
Role in Herbal Toothpaste	• Mild abrasive for plaque removal
Benefits in Oral Care	• Safely removes plaque without damaging enamel
• Helps remineralize enamel	
Concentration Used in Toothpaste	20–45% in commercial pastes; **3–5%** in herbal formulations like yours
Toxicity / Safety	Non-toxic, GRAS (Generally Recognized as Safe)
Compatibility	Compatible with glycerin, sorbitol, herbal extracts, essential oils; incompatible with acidic ingredients
Examples of Natural Sources	Limestone, marble, sea shells, chalk
Storage Conditions	Store in airtight container, cool and dry place, away from acids and moisture

Figure 10 Calcium Carbonate

Glycerin:-

Glycerin acts as a humectant, helping retain moisture in the toothpaste and preventing it from drying out. It contributes to smooth texture, eases dispensing from the tube, and provides mild sweetness. It also aids in the uniform dispersion of herbal extracts throughout the formulation.

Table 5 Description of Glycerin

Parameter	Details
Chemical Name	Glycerin / Glycerol
Chemical Formula	$C_3H_8O_3$
Source	Naturally derived from plant oils (coconut, palm) or synthetically produced.
Appearance	Clear, colorless, odorless, viscous liquid.
Taste	Sweet, non-toxic.
Solubility	Miscible with water and alcohol.
pH	Neutral (approx. pH 7).
Role in Toothpaste	Humectant (moisture retention), smooth texture development, prevents drying, gives shine, mild sweetener.
Concentration Range in Toothpaste	Typically 2–20% depending on formulation.
Functions	• Prevents toothpaste from drying
Benefits in Herbal Toothpaste	Works well with herbal extracts; maintains moisture of plant-derived ingredients; prevents microbial growth by reducing water activity.
Safety Profile	GRAS (Generally Recognized as Safe); non-irritant, non-toxic.

Figure 11 Glycerin

Para-hydroxy Benzoic Acid (Preservative):-

Para-hydroxy benzoic acid (a type of paraben) functions as an antimicrobial preservative that prevents growth of bacteria, fungi, and molds within the formulation. It enhances shelf-life and maintains product safety and stability by inhibiting microbial contamination during storage and use.

Table 6 Description of Para- Hydroxy Benzoic Acid

Parameter	Details
Chemical Name	Para-hydroxy benzoic acid
Common Name	PHBA
Category	Preservative (parent compound of parabens)
Chemical Formula	$C_7H_6O_3$
Molecular Weight	138.12 g/mol
Physical Appearance	White crystalline solid or powder
Odor	Odorless
Solubility	Slightly soluble in water; highly soluble in ethanol, acetone, and other organic solvents
Melting Point	~210 °C
Stability	Stable under normal conditions; resistant to microbial degradation
Mechanism of Action	Inhibits microbial enzymes, disrupts cell membrane integrity, prevents growth of bacteria & fungi
Primary Function in Toothpaste	Acts as a preservative to prevent microbial contamination and extend shelf life
Role in Herbal Toothpaste	Protects natural plant extracts from spoilage; maintains product safety and quality
Effective Concentration Range	Typically **0.1–0.5%**

Compatibility	Compatible with most toothpaste ingredients (glycerin, calcium carbonate, herbal extracts)
Advantages	Highly effective at low concentrations, broad-spectrum antimicrobial action, cost-effective
Safety & Toxicity	Considered safe at low cosmetic levels; excessive use may cause irritation in some individuals
Regulatory Status	Allowed in cosmetic and oral care products within restricted limits as per national regulatory guidelines
Storage Conditions	Store in a cool, dry place away from moisture; stable in sealed containers
Shelf Life	Long; typically 3–5 years when properly stored

Figure 3 Para-H- Benzoic acid

Sodium Lauryl Sulfate (Surfactant):-

Sodium lauryl sulfate (SLS) is a widely used surfactant and foaming agent. It helps lower surface tension, allowing the toothpaste to spread easily and effectively remove debris. The foaming action enhances user experience and contributes to improved cleaning efficiency. In herbal formulations, its concentration is kept minimal to avoid irritation.

Table 7 Description of S-L-S

Parameter	Details
Chemical Name	Sodium Lauryl Sulfate
Synonyms	Sodium dodecyl sulfate (SDS), SLS
Chemical Formula	$C_{12}H_{25}SO_4Na$
Molecular Weight	288.38 g/mol
Chemical Structure Type	Anionic surfactant
Source	Synthetic (derived from lauryl alcohol of coconut or palm oil)
Physical Appearance	White to off-white powder, flakes, or viscous gel
Solubility	Highly soluble in water
Surfactant Type	Anionic
HLB Value	~40 (Highly hydrophilic)
pH Range (1% solution)	7–10
Foaming Ability	Very high; produces stable and rich lather
Primary Function in Toothpaste	Foaming agent – helps spread toothpaste uniformly and aids in cleaning action
Secondary Functions	Detergent (removes debris), Emulsifier (helps mix oil & water), Wetting agent
Role in Cleaning	Reduces surface tension → loosens food particles, plaque, and oils from teeth
Benefits in Oral Formulations	Enhances cleansing efficiency; gives desirable foamy texture; increases dispersion of actives
Concentration Used in Toothpaste	Typically 0.5 – 2%
Stability	Stable at room temperature; stable across broad pH range
Compatibility	Compatible with most ingredients except strong cationic substances
Irritation Potential	Possible mild irritation (mouth ulcers in sensitive individuals) at higher levels

Toxicity	Generally recognized as safe at low concentrations (<2% in oral care)
Biodegradability	Readily biodegradable
Regulatory Status	Approved for use in personal care by FDA, EU cosmetic regulations (with concentration limits)
Common Applications	Toothpaste, shampoos, face washes, detergents, soaps, shaving creams
Shelf Life	~2 years (depending on storage conditions)

Figure 13 S-L-S

Sodium Chloride:-

Sodium chloride (common salt) provides mechanical cleansing and acts as a mild abrasive. It also has natural antiseptic and astringent properties that help strengthen gums and minimize inflammation. Additionally, it contributes to ionic balance and enhances overall oral hygiene.

Table 8 Description of Sodium Chloride

Parameter	Description
Chemical Name	Sodium Chloride
Common Name	Table salt / Common salt
Chemical Formula	NaCl
Appearance	White crystalline powder or granules
Solubility	Highly soluble in water
Taste	Salty
Odor	Odorless
Role in Toothpaste	Mild antiseptic, astringent, cleansing agent
Primary Function	Helps reduce inflammation of gums; assists in mechanical cleaning of teeth; maintains ionic balance in formulation
Mechanism of Action in Oral Cavity	Exerts osmotic effect that reduces microbial growth and alleviates swelling; promotes gingival tightening
Benefits for Teeth & Gums	Reduces gum swelling, decreases oral bacteria, freshens mouth, aids in plaque removal
Use Level (Typical)	0.1%–1% depending on formulation
Quantity Used (Your Formulation)	0.2%
Compatibility	Compatible with abrasives, humectants, herbal extracts, and most preservatives
Stability	Very stable; does not degrade; long shelf life
Safety Profile	Generally recognized as safe (GRAS); non-irritant at low concentration
Potential Side Effects (Higher Concentration)	May cause slight irritation or salty taste if used above optimal levels
Reason for Inclusion in Herbal Toothpaste	Enhances gum health, improves cleansing action, provides mild antimicrobial effect, balances formula
Physical Role in Formulation	Helps maintain product viscosity and ionic strength
Nature	Inorganic salt, natural mineral
pH Behavior	Neutral; does not significantly alter toothpaste pH
Regulatory Status	Approved for oral care formulations globally

METHODOLOGY FOR TOOTHPASTE PREPARATION

Collection and Processing of Herbal Materials:-
The herbal raw materials required for the formulation—Neem stem and bark, Babul leaves, Guava leaves, and Kalmi bark—are collected from authenticated botanical sources or local herbal suppliers. Each material undergoes the following processing steps:-

- **Cleaning:** Fresh leaves and bark are washed thoroughly under running water to remove dust, soil, and microbial contaminants.
- **Drying:** Materials are shade-dried for 7–10 days to preserve phytoconstituents and prevent thermal degradation.
- **Powdering:** The dried materials are ground using a mechanical grinder and passed through a sieve (60–80 mesh) to obtain fine, uniform herbal powders.
- **Storage:** The powders are stored in airtight containers away from direct sunlight and moisture until used in formulation.

Extraction Techniques (if applicable):-
If extracts are preferred over powdered herbs, the following steps may be employed:

- **Solvent Extraction:** Herbal samples are subjected to hot or cold maceration using distilled water or hydroalcoholic solvents.
- **Filtration:** Extracts are filtered through muslin cloth and Whatman paper to obtain clear solutions.
- **Concentration:** The filtrate is evaporated at low temperature using a water bath or rotary evaporator.
- **Drying:** Concentrated extracts are dried to obtain semisolid or powdered extracts for incorporation into the toothpaste base.

Note: The attached formulation table uses **0.5 g of powdered herbal materials**; therefore, extraction is optional and formulation can proceed directly with powdered forms.

Figure 4 Extraction Process

Mixing and Blending Procedure:-
The toothpaste is prepared using a stepwise blending method to ensure uniform dispersion of ingredients:

1. **Preparation of Abrasive Base:**
   - Calcium carbonate (3.5 g) is weighed and mixed thoroughly to form the primary abrasive body.
2. **Preparation of Humectant–Sweetener Phase:**
   - Glycerin (2.0 g) and honey (0.5 g) are mixed to create a smooth, viscous phase that prevents dryness and enhances texture.
3. **Hydration of Herbal Powders:**
   - Neem, Babul, Guava, and Kalmi bark powders (each 0.5 g) are gradually dispersed in a small portion of distilled water to form a uniform slurry.
   - This ensures smooth blending and reduces lump formation.
4. **Combining Phases:**
   - The herbal slurry is added to the abrasive base with continuous stirring.
   - Glycerin–honey phase is incorporated slowly to achieve proper homogenization.

5. **Incorporation of Surfactant:**
   - Sodium lauryl sulfate (0.5 g) is added carefully to avoid excessive foaming during mixing.

Figure 5 Mixing of all Ingredients

6. **Addition of Preservatives and Additives:**
   - Camphor (0.5 g), sodium chloride (0.2 g), and para-hydroxy benzoic acid (0.3 g) are blended into the mixture.
7. **Adjustment with Distilled Water:**
   - Distilled water is added **10 ml** to obtain the desired consistency of toothpaste.
8. **Final Homogenization:**
   - The mixture is passed through a colloid mill or mechanical stirrer to ensure uniform, smooth, and lump-free toothpaste.
9. **Filling and Packaging:**
   - The final product is transferred into laminated or collapsible tubes and sealed.

Preparation Flowchart:-

Collection of Herbal Materials
↓
Cleaning and Shade Drying
↓
Powdering and Sieving
↓
Weighing of Ingredients (as per formulation table)
↓
Preparation of Herbal Slurry
↓
Blending with Abrasive Base (Calcium Carbonate)
↓
Addition of Humectants (Glycerin, Honey)
↓
Incorporation of Surfactant (Sodium Lauryl Sulfate)
↓
Addition of Additives (Camphor, Preservative, NaCl)
↓
Adjustment with Distilled Water (q.s.)
↓
Final Homogenization
↓
Filling and Packaging in Tubes

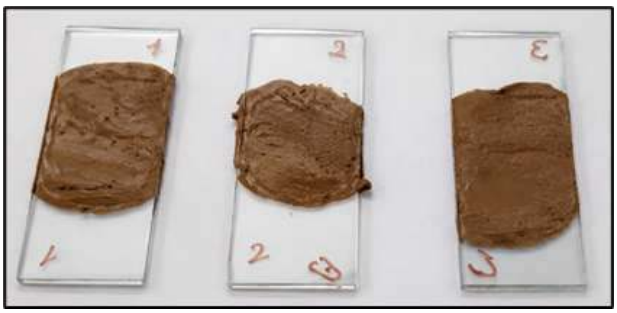

Figure 17 Formulation F1, F2, F3 Respectively

Figure 18 Label for Formulation

EVALUATION PARAMETERS FOR HERBAL TOOTHPASTE

Physical Evaluation:-

- **Color:-** Light brown / greenish brown colour observed
- **Odor:-** Like Neem, Camphor Strong Smell
- **Appearance:-** Smooth, homogeneous paste obtained

Figure 6 Evaluation of Color, Odor, and Appearance

- **pH Measurement:** Measured using pH meter

Figure 7 PH Measurement

PH found between 6.5 – 7.5

- **Spreadability:-** Paste spread on glass slide

Observation :- Good spreadability observed

- **Texture & Consistency:** Ensures smoothness, proper thickness, and user comfort.

Figure 21 Spreadability

Chemical Evaluation:-

- **Foamability:** Assesses the ability to form foam during brushing.

Figure 8 Foamability of toothpest

- **Moisture Content (short):** Determined by drying method
  Observation:- Acceptable moisture content observed

Microbiological Evaluation:-

Antimicrobial Activity: The antimicrobial activity of the herbal toothpaste was evaluated by agar well diffusion method against common oral microorganisms such as Streptococcus mutans and Lactobacillus species. The zone of inhibition was measured after incubation.

Figure 23 Microbiological Evaluation

Observation:- The herbal toothpaste showed good antimicrobial activity with a noticeable zone of inhibition against oral pathogens, indicating effective reduction of microbial growth responsible for dental caries and bad breath.

- **Total Microbial Load:** Confirms the product meets safety limits for contamination.

RESULT

The prepared herbal toothpaste formulation showed satisfactory physical, chemical, and antimicrobial properties. The combination of herbal ingredients such as neem, babul, guava leaves, kalmi bark, camphor, and honey provided effective antibacterial, anti-inflammatory, and gum-strengthening activity. Calcium carbonate acted as a mild abrasive for plaque removal, while glycerin maintained smooth texture and moisture. Sodium lauryl sulfate produced good foaming action and improved cleansing efficiency.

The formulated toothpaste was light brown to greenish-brown in color with a pleasant herbal odor and smooth consistency. The pH was found to be between 6.5–7.5, which is suitable for oral use. Good spread ability, acceptable moisture content, effective cleaning ability, and satisfactory stability were observed without phase separation or color change during storage.

Microbiological evaluation showed noticeable antimicrobial activity against common oral pathogens such as *Streptococcus mutans* and

Lactobacillus species, indicating effective protection against plaque, bad breath, and dental caries.

Overall, the herbal toothpaste formulation proved to be safe, effective, economical, and suitable for maintaining oral hygiene naturally with minimal side effects.

CONCLUSION

The present review highlights the potential of herbal ingredients in the development of an effective, safe, and economical toothpaste formulation. The combination of Neem, Babul, Guava leaves, Kalmi bark, camphor, honey, and other natural components offers significant antimicrobial, anti-inflammatory, and cleansing properties, which collectively contribute to improved oral hygiene. The inclusion of conventional excipients like calcium carbonate, glycerin, surfactants, and preservatives ensures adequate texture, stability, spread ability, and shelf-life of the formulation.

Evaluation studies demonstrate that herbal toothpaste can provide comparable or superior benefits to synthetic formulations while minimizing side effects associated with chemical additives. The results support the growing preference for herbal oral-care products and validate the scientific basis for their therapeutic applications. Overall, the formulation reviewed in this study represents a promising natural alternative for maintaining oral health, and further research on standardization, optimization, and large-scale production could advance its commercial potential.

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